DVM CIRCUIT DESCRIPTION AND TROUBLE SHOOTING GUIDE

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Supplement 1 A/D converter, LD120 by Siliconix
Supplement 2 RMS chip, AD536A by Analog Devices

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DVM 56 CIRCUIT DESCRIPTION

The DVM 56 is a unique instrument providing standard features and some new features never seen on a multimeter before yet has simplified panel controls and operation that belie the complexity inside. All of this is possible, of course, because the DVM56 is controlled with a microprocessor chip. The special features of zeroing out internal resistance and lead resistance on ohms, establishing any dB reference with the press of a button, the fast autoranging that quickly sets the correct range for the measurement, the "thinking time" that blocks out all readings until the final result is ready, the extended ohms range to 100 megohms on the high end and to zero on the low end since lead resistance and internal resistance can be zeroed out, the three ACV measurements that cover all possible measurement data published in service literature, PP volts, ave. RMS volts calibrated in RMS and true RMS voltage measurements, the special DC scale that gives direct readings with a 10X probe for complete safety of the instrument and operator when working in high voltage circuits, the high and low power ohms ranges--low power for in-circuit measurement and high power for checking semiconductor junctions, the range hold feature which will lock out the autoranging above and below the range being held in especially useful for troubleshooting, the peak and null indicator which allows fast, accurate settings of controls comparable to an analog indication, and lastly and possibly the most important feature is that the display mode can be selected to be 3½, 4, or 4½ digit permitting the least significant digit, which is often changing, to be shown only when the measurement requires 4½ or 4 digit precision. A built-in feature that one might not realize exists is the auto zeroing of the A/D every time the function switch is rotated to DC volts position. This operation takes a second or two to accomplish but is believed to be well worth the slight delay for the increased accuracy that results, when all measurement path offsets and extraneous voltages are cancelled out from the measurements. If the meter sets unused, but on for a long period it might be desirable to rotate the function switch to an adjoining function and then back to initiate the auto zero prior to making a new measurement.

All of the circuitry to accomplish these features is provided on eight small printed circuit boards housed in relatively small cabinet 4¾" high by 8" wide by 11" deep. Four of the boards, the controller board that has the UP memory, the A/D board, the ohms and current board and the AC board are all housed in a shielded compartment to reduce the chance of spurious signals from affecting the measured reading. The four boards just mentioned are edge connected to an interconnect board mounted on the outside of the compartment. The three remaining boards are the display board, the power supply and a board used for mounting and interconnecting the special function push switches.

A simplified block diagram showing the circuits necessary to provide the functions of the DVM56 is shown in Figure 1. Each major block shown represents one of the printed circuit boards just discussed above except the interconnect board per se, it is not shown as it does nothing to help one understand the circuit. It is shown on the more detailed block diagram, figure 2, where one can trace all connections through the system to aid in the troubleshooting.

Referring to Figure 1, note that the power supply block in the lower right of the diagram serves two purposes. First it takes the ACV from the power transformer and through rectifiers, filters, and regulators develops the DC supply voltages needed to drive the various circuits. Second, the heavy duty current shunts are also located on the power supply board for power dissipation and to keep the heavy leads as short as possible.

The meter input jacks are completely isolated from AC third wire ground and are allowed to float when measurements are made above or below third wire ground potential. The DVM56 case and chassis is connected to 3rd wire ground for operator protection. A gas discharge device will fire if the negative input lead goes more than 1500 volts above or below the chassis, however. Also, a spark gap placed between the + and - input jacks is set for 2100 volts to keep excessive voltages from getting into the DVM56 circuitry.

Two ground networks are used, one ground for power supply currents and the other ground for signal currents called analog ground. All grounds, analog ground, and power supply grounds came together on the A/D board right at the A/D chip. The reason for the double grounding system is to keep spurious signals and voltages on the power supply from interferring with or affecting the measured reading. Note that the lead from the negative input jack goes first to the current shunts on the power supply board then to the common ground on the A/D board. Again, it goes to the shunts first to keep lead length as short as possible for least drop to the external circuit being measured.

The positive input jack is connected directly to the function switch through two 2A fuses in series--a 250V rating and a 1000V rating. The 1000V fuse is necessary for protection of the instrument when it is misapplied to high voltage, high power sources such as a 440 or 660 main. Unfortunately, for lead length that is, the fuses have to be mounted on the rear panel, but most of the run is along an analog ground shielded area and AC pickup is insignificant. It does add a bit more voltage burden on current measurement but not significant.

From the function switch the input is distributed via separate connection, not the interconnect board, to the A/D board for DC voltage, to the ohms board for high and low power ohms to the AC board for PPv, ave. Rms volts, true RMS volts, dBm and dBp, and to the current shunts on the power supply board for AC current and DC current measurements. The input to the ohms board is fused and also protected with a 75V gas discharge device to protect the ohms circuitry.

The input connection and ground connections were discussed in some detail above because they won't be covered again in this discussion. Now we would like to cover the basic circuits in very broad terms. These will be covered in much greater detail in later discussion. Refer to Figure 1.

MICROCONTROL:

The uP chip and memory are located on the controller PC board, upper left main block on Fig. 1. There are two sets of control lines to other circuits. If one were looking at a wired unit, the most obvious are the lines that connect to the back of the interconnect board from the function switch and the display board. Most of the connections on the molex plugs to the back of the interconnect board make up the data buss, which sends the position of the function switch to the uP, See Fig. 1 and then later provides measurement information to the display. One of the data bus lines is also used when the zero ohms/dBp button is pushed.

Range control, A/D sensitivity, and timing of the display are controlled by access lines other than the data buss as shown in Fig. 1.

During most of the time the DVM56 is operating, the uP is controlling the A/D chip. When the microcontroller and the A/D are both operating properly, we have reached the point where we have digitally replaced an analog meter. From here on it is simply a matter of providing a voltage to the A/D and the A/D will turn it into data that will be displayed digitally. The function has already been preselected with the function switch so the symbols associated with that function will automatically be selected by the uP. The range will be controlled by the level of the applied voltage. If the input voltage is over the lowest range of the function, the over range condition will be signaledto the uP (unless the range hold button is activated) and the uP will send out the proper signals to cause the range control circuits for the function to change to the next highest range, or if the input voltage is less than approximately 9% of the range, the range will be reduced to the next lowest range.

A/D INPUT

As you probably have noted by now, the A/D chip is located on the second large block down on the left of Fig. 1. Note that the input to the A/D is through a low pass filter that rejects high frequency noise or fast sudden surges. Input to the filter is an equivalent DC voltage proportional to DCV, Ohms, DCC, ACV PP or ACV rms (true or average), as selected by an input selector switch. The input switch is controlled by the front panel function switch through the uP controller.

If the DCV function is selected, the input comes from the function switch to a divider on the A/D board which is range controlled by the uP, and then to the A/D selector switch just discussed above. If ohms, ACV or currentsfunctions were selected, the inputs to the A/D selector switch comes from the ohms board or the AC board.

The same signal that feeds the A/D is also used to drive the peak and null circuitry. A buffer amplifier is located on the A/D board, and the peak and null detector is located on the controller board. The output of the detector drives two LEDs on the display board. Note that the peak and null feature can be used with any of the DVM56 functions, be it AC or DC current, AC or DC volts, ohms or dB. This, of course, is in keeping with analog multimeters.

OHMS

The ohms circuitry used in the DVM56 is quite standard for ohms measurement with digital meters. It is necessary to produce a known constant current at the input jack to be fed into the resistor being measured. Then the voltage developed across the unknown resistor changes linearly with the value of the resistor, and the readout can be calibrated directly in resistance.

The constant current at the input jack changes with each ohms range by changing the internal standard resistor, by changing the voltage across the standard resistor or through a combination of both. All range changing is done with the uP.

The constant current that is applied to the unknown resistor is developed by first generating a constant current from a fixed zener voltage source. This unchanging current is used in the feedback path of an op amp to develop very accurate 1V or 10V DC at the output of the op amp. This voltage is placed across one of the internal standard resistors to develop the appropriate constant current at the input jack for each ohms range.

The entire current generating circuit is allowed to float above analog ground do that the voltage developed across the unknown resistor does not change the voltage across the internal standard resistor. Thus the constant current is truly constant for accurate measurements. The voltage devoloped across the unknown resistor, of course, is with respect to the analog ground. A buffer output is used to convert the high impedance measuring circuit to a low impedance output that goes to the input selection switchoon the A/D board.

AC VOLTAGE

Five different methods of measuring AC voltage are provided on the DVM56: PP measurements, average measurements calibrated in RMS, true RMS measurements, dBm and programmable dB. All of this circuitry is located on the AC board, bottom left corner of Fig. 1. As with DC volts, the AC is applied to a divider directly from the function switch. Range control of the divider is controlled by the uP and the output of the divider is fed to either of two circuits as selected by the function switch, the RMS processing circuit or the peak to peak processing circuit. The RMS processing circuit is also used for AC current measurements and for dB measurements. The AC voltage developed across the shunt resistor on the power supply board during an AC current measurement is coupled to the ohms board and then through a buffer to the AC board where it will feed the RMS processing circuit. No special circuitry is required for dB calculations as this is handled completely with the software. Average RMS voltage measurements are made by changing the RMS processing circuit to an absolute value circuit and then multiplying the output by 1.11 in the uP.

The two outputs from the AC board, P-P & RMS are coupled to the A/D board to the input selector switch.

DISPLAY AND SPECIAL FUNCTIONS

The display board shown on the middle right side of Fig. 1 is controlled primarily by the uP for digit and legend control, but is also manually controlled with the display switches to make the DVM56 a 4½, 4, or 3½ digit meter. The peak and null indicators as mentioned above continously receive information from the peak and null detector on the controller board when a measurement is being made, but will only indicate when the circuits are completed with the peak and null pushbutton switch.

Range hold, ohms zero, and dB programmable reference are in the uP software which is activated when the range hold pushbutton switch or the combination ohms and dBp zero pushbutton switch is pushed.

Be sure you develop a good understanding of how the different functions are processed in the DVM56. Remember that most functions involve circuits on several different boards, and to fully understand and be able to troubleshoot the DVM56 efficiently you should memorize signal flow. The block diagram in Fig. 2 is much more detailed and can be used to trace connection lines from board to board and should prove invaluable when tracking down a trouble but wires and connections are not often the cause of a trouble so knowing which boards are involved with each function will be more helpful in quickly getting to the source of the problem.

To summerize signal flow, let's review what has been covered: Input Jacks: The negative jack is analog ground and makes connection to the common ground at the A/D chip through the power supply board. The positive jack first goes through two fuses in series on the rear panel and then to the function switch where the input is distributed to the power supply board for current measurements, to the ohms board through another fuse on the rear panel for ohms measurements, to the A/D board for DC voltage measurements, and to the AC board for AC voltage measurements, including dB.

Current measurement: Two identical ranges are provided for AC and DC measurements with the current shunts located on the power supply board. The same shunts are used for AC and DC. The voltage developed across the shunts is coupled to the ohms--current board where a selected amount is chosen for calibration. If DC current is being measured, the calibrated voltage is routed to the A/D through the A/D input selector switch for processing. If AC current is being measured, the calibrated voltage goes through a buffer amplifier on the ohms--current board, then to the RMS processor circuit on the AC board and finally to the A/D through the A/D input selector switch for processing.

Ohms measurement: Two modes of ohms measurement are possible from the front panel, low power and high power. Low power develops a maximum of 0.2V across the highest value of resistor measured, on each range, and high power a maximum of 2V, except for 100 megohm which goes to 10V. The 10V is divided by 10 so the A/D receives a maximum of IV with a 100 megohm resistor. Ohms circuitry is all confined to the ohms--current board. A constant current is generated to be applied to the unknown resistor. The ensuing voltage developed across the resistor, which is a direct measure of resistance, is buffered in a buffer amplifier on the ohms--current board and then routed to the A/D through the A/D input selector switch for processing.

The DVM56 autoranges to the proper range for the resistor being measured, with the uP selecting the proper combination of standard internal voltage (one or ten volts) and standard resistor, 1K, 100K or 10 meg to generate the necessary standard current.

DC voltage measurement: DC voltage measurement involves the least circuitry of all functions. The voltage is delivered to the DC divider on the A/D board and then a selected amount goes to the A/D through the A/D input selector switch. Two ranges are provided on the input divider and the A/D also has two ranges for a total of four DCV ranges all autoranged and controlled with the uP.

AC voltage measurement: Five different forms of AC voltage measurement are provided from the front panel--peak-to-peak, average RMS, true RMS, dB referenced at 1mV into 600 ohms and dB with programmable reference. All circuitry for AC measurement is provided on the AC board, the block in the lower left corner of Figure 2. DB measurements do not entail any extra circuitry, as all calculations are performed in the uP software.

AC voltage is applied to a compensated divider, where three ranges are provided: 0-20, 200, & 2000 volts. After the voltage is divided down, it is applied to the peak-to-peak processing circuit for peak-to-peak measurement and to the RMS processing circuit for RMS measurement. The outputs of both circuits are applied to the A/D through the input selector A/D switch. Average RMS measurements are processed by using the true RMS circuit as an absolute value circuit (essentially a full wave output) and multiplying this output by 1.11 in the uP.

Peak & null: The peak and null function involves circuits on four different boards. The same signal that is applied to the A/D is also applied to a peak and null buffer on the A/D board, then to the peak and null detector on the controller board and finally to the peak and null indicators on the display board. The indicators will not be activated however until the peak and null switch on the switch board is activated.

Range hold: Range hold, activated any time the Range hold button is pushed, will hold any range of any function the DVM56 is in at the time the button is pushed.

Now that we have a good understanding of how each function is processed and routed in the DVM56, let's look at general operation of the instrument and then at each circuit in detail to see how the various functions and measurements are made.

DVM56 OPERATION

Everything that happens in the DVM56 during a measurement is controlled by the uP, IC2 on the controller board, (see Controller Board Schematic, Fig. 3). First the uP reads the function switches to determine the setting and will then output the signals necessary to drive the display and the indicator lights. It senses the proper range needed to display the measurement and controls the range switching circuitry in the different circuits to achieve this end. It also provides the logic and control to the A/D converter. Controlling the A/D converter actually takes most of the operating time of the uP, amounting to 70% to 75%.

The uP is programmed by a program stored in a ROM chip, IC4, and is accessed through the data bus, uP pins 12-19, and additional lines, pins 21-23 and pin 25. An instruction will be fetched in the following manner.

1. The contents of the 12 bit program counter will be output on BUS and the lower half of port 2.
2. Address Latch Enable (ALE) will indicate the time at which address is valid. The trailing edge of ALE is used to latch the address externally.
3. Program Store Enable (PSEN) indicates that an external instruction fetch is in progress and serves to enable the external memory device.
4. BUS reverts to input mode and the processor accepts its 8 bit contents as an instruction word.

The 8035 processor without program memory always operates in the external program memory mode (EA=5V).

The uP controls the digital display through the data bus and the SYNC and WR lines in the following manner. Segment data is carried by the data bus to the display latches. The WR line is used to latch the segment data in the display latches and to clock the digit sequencer. The SYNC line comes from the digit sequencer to the uP to keep the microprocessor syncronized to the digit sequencer. This will make certain the uP will output the correct segment data for each digit.

TR7 inverts the WR line from the uP for proper polarity and edge speed for use in the display board.

The uP also receives data from the function switch through the data bus. To read the function switch position, the RD line turns on three 4016 switches, IC6A, B, & C. These switches will pull certain data bus lines low as selected by the function switch. The uP then reads the data bus and determines the position of the function switch.

Port one of the uP, pins 27-34, is used to set the autoranging circuitry to the proper range. Each range of each function has a code. These are listed below in Table 1. The eight bits of each range data byte are parallel outputs on each port one line. Reading from left to right on the data byte corresponds to pins 34-27 respectively on Port one. Since this is cumbersome to use, a table is provided on each range control line on every schematic to aid in troubleshooting.

As indicated previously, the uP spends most of its time controlling the A/D converter, IC2 on the A/D converter and DC volts board schematic, Figure 4. The A/D converter is controlled by two output lines and one input line from the uP, pins 37, 38, and 6 respectively. The input line on pin 6 has been inverted and level shifted by transistor TR6.

One output line, pin 37 switches the A/D from zero mode to convert mode. The other output line, pin 38, changes the polarity of th integrator so it either ramps up or down. The input line, pin 6, comes from a comparator to tell if the integrator output is above or below ground. By measuring the amount of time that the integrator in the A/D ramps up and subtracting from this the amount of time the integrator ramps down, the input voltage to the A/D can then be determined.

For example: 50% up = OV 25% up = -1.0V

75% up = 1.0V 5% up = -1.8V

95% up = 1.8V

IC7 and IC8 are address latches for memory chip IC4, Figure 3, and IC3 is a "real time" keeper that is used with the A/D chip to keep the A/D accurate. L1, C5 and C6 comprise the tuned circuit of a 5 MHz oscillator for IC2.

TR8, TR9, IC9 and associated parts provide a filter to the DVM input and also makes up a circuit that will reset the uP if it locks up as it is sometimes prone to do when measuring a high voltage.

The 4½ digit A/D converter used in the DVM56 is one half of a set of chips developed by Siliconix. Only the A/D chip itself is used; the control chip functions are provided by the uP. Operation of the A/D chip is quite involved and rather than attempt to redo what already has been done, the pertinent description sheets from Siliconix describing operation are included here for those that want a detailed description of operation. See supplement number one.

The important point to remember at this time is that the A/D with the uP, converts all measurement data taken with the DVM56 into data for the digital display. The input to the A/D of course is in the form of a positive or negative DC voltage. All functions are converted to DCV for application to the A/D: ACC, DCC, ohms, and ACV. The input voltage is selected with IC4 and L2 or L1 (Fig.4).

One other point to remember is that the A/D has two ranges: Selection of the range used is thru solid state switch IC5. The low range, 0-0.2V, is used for low power ohms, DC current and the 2V and 200V DC voltage ranges. The high range 0-2V is used for all other functions.

In further discussion, we will show how each of the measurements be it ohms, current, or voltage arrives at the input to the A/D in the form of DC volts. But first let's discuss the display circuit to see how these DC voltages at the input to the A/D become numbers in the display.

As mentioned previously, the A/D works with the uP to change a DC voltage to a number that can be displayed digitally. Since LED displays, the type used in the DVM56, consume quite a bit of power when all segments are turned on simultaneously, it has been common practice to multiplex the voltage to the displays so that each digit is on only a fraction of the time. One does not see this, however, as the persistance of the eye will make it appear that the digit is on continuously.

The uP generates digit segment data (seven segment digits are common and are used in the DVM56) and digit sequence data to drive the digital display.

Refer to Figure 5, the Digital Display Board, i.e., Schematic. Segment data and legend LED data is delivered via the uP data bus to two display latches IC2 and IC3. The WR signal from the uP is used to latch the segment data and legend LED data in the display latches and also clocks the digit sequencer, IC1 through transistor TR1. No phase inversion results as TR1 is connected common base. The digit sequencer is a divide by eight counter/divider with eight decoded outputs. Each output drives one of the digits or a cluster of legend LED's in sequence. Thus only one digit can be on at a time as we just discussed above. The "0" output from IC1 is used to reset the counter divider through TR2 and C1 and also is output to the uP through the SYNC line to keep the uP synchronized to the

digit synchronizer. This insures that the uP will output the correct segment data for each digit.

In the absence of a WR signal, TR2 is cut off, IC1 reset is held high through R3 and the display will be completely off for protection of individual display segments.

IC1 is a CMOS device incapable of driving LED displays directly, therefore, transistors TR3-9 are used to provide the necessary driving power. Likewise segment driver transistors TR10-17 are used to provide the necessary segment driving power.

Display D4 & D5 are made inoperative when the three digit front panel display button is pushed and display D5 is made inoperative when the 4 digit display button pushed. All displays operate when the 4½ digit display button is pushed.

The peak and null indicator LEDs are completely separate from all other circuitry on the display board. Peak and null signals are delivered to the LEDs anytime a measurement is being made but the LEDs are not activated unless the front panel peak and null button is pushed.

PEAK AND NULL

Refer to Figures 3 and 4. The same DC voltage that feeds the A/D also feeds amplifier IC1 on the A/D board, Figure 4. IC1 is a non inverting amplifier with a gain of 10, but with back to back 2V zener diodes in the feedback path which limits the output to approximately +2V with respect to ground. Figure 6 shows the typical response curve. The high gain is required so that small level changes can be readily detected and, of course, limiting is required to keep the signal output from running into the + rails on IC1. The output from IC1 connects to the peak and null detector on the A/D board, Figure 3.

The peak and null detector consists of IC1, TR1 and TR2. IC1 is connected as an inverting amplifier with a ground reference. The input signal is AC coupled through C2 and C3. The gain of the amplifier is approximately 200, so that very small input signal reversals will cause the output to swing from rail to rail. Actually the output cannot swing from rail to rail because transistors TR1 and TR2 will limit the output to +5 volts. TR1 will conduct if the output tries to go above +5 volts, TR2 will conduct if the output tries to go below -5 volts. Diodes CR1 and CR2 prevent the emitter base junctions of TR1 and TR2 from zenering when the junctions are reversed biased.

Since the input to IC1 is AC coupled only the changes in a measurement come through such as when going through a peak or a null. If no change is occuring, the output of IC1 will be near ground. An output will also be present when a measurement is continually changed in the same direction if the change is made fast enough.

The output of IC1 feeds the null LED current buffer driver TR4 directly and the peak LED current buffer driver, TR3 through inverter IC5. IC5 is connected to have a gain of one. When the peak and null front panel switch is closed both LED's connect to -7.5V on one connection. The other LED terminals connect to R10 and R11 respectively.

When no change in the measurement exists the bases of TR3 and TR4 will be at or near ground, and both peak and null LEDs should light with about the same intensity. A change in the measurement will cause one LED to get brighter and the other to get dimmer. Thus, it is relatively easy to tell when going through a peak or null when making a measurement.

DC VOLTAGE MEASUREMENT

When a DC voltage measurement is being made, DC voltage at the DVM56 input jack is routed through the front panel function switch to the resistor divider R1-R9 on the A/D board, Fig. 4. Four DC voltage ranges are provided in the DVM56: 0-2V, 20V, 200V, and 2000V or 0-20, 200, 2000 and 10,000V when the transient protection probe TP222 is used. The only difference in the DVM56 to the DCV position with the probe to the position without the probe is that the decimal is shifted one place to the right (X10) with the probe, and the readout overranges at 10KV. Range selection is determined by the uP through inputs to TR1 and IC4 as noted at the inputs of control pins 12, 14, 16, and 18 marked on the schematic.

Voltage is picked off of the divider between R5 and R6 and is fed to the A/D through relay L1 in the 2V and 20V ranges. In the 200V and 2 KV ranges voltage is picked off of the divider between R7 and R8 fed through solid state switch IC4 and then through relay L2 to the A/D.

As stated previously the A/D also changes ranges on DCV operation: 0.2V range for 2V and 200V, 2V range for 20V and 2 KV. This is quickly confirmed by noting that the pick off for 2V and 20V ranges is one-tenth of the input voltage adjustable with R7, and the pick-off voltage for the 200V and 2000V ranges is one/one thousandth of the input voltage, adjustable with R8.

TR1 drives relay L1 and TR2. TR2 drives relay L2. NOte from the operating data on the range control lines that in the 2V and 20V ranges the base of TR1 is held low, which in turn makes the emitter go low turning on L1 and cutting off TR2. In the 200V and 2KV ranges, the range control line is high, L1 opens and L2 closes. Also the range control lines to IC4 are such that the input voltage on pin 12 is switched to the output on pin 3 completing the circuit.

The DVM56 is completely autoranging on all functions ranging upwards when the uP senses that the measurement exceeds the range the DVM56 is in or ranges downward when the uP senses that one count is below 1800 or approximately 9% of the range. Thus the readout will follow any measurement that is varied up or down across ranges.

A range hold button when activated prevents the DVM56 from autoranging and will hold any range that the DVM56 may be in at the time the button is pushed. If the function switch is changed with the hold button in, however, the lowest range of the new function will be held. Switching off and then back to the same function with the range hold button in will also cause the lowest range to be held.

A unique feature not readily apparent on the DVM56 is the automatic zeroing that takes place every time the function switch is switched into a DCM position. This takes place by L1 opening, L2 closing and recording any input voltage that might exist with respect to ground on pin 5 of IC4. This amount is then subtracted from the reading to insure an absolute DVC zero.

The low pass filter, IC3 looks rather strange when first observed on the schematic, because the input and output appears to be shorted together. Of course, this assumes the signal is supposed to go through the filter, which it does not do. What does happen is that a small change in level at the output of R12 couples through C8 to a high gain inverting amplifier IC3. The output of IC3 couples right back to the starting point through C9. Obviously

the input can't change very far before there is an immediate correction back through C9. Very low frequencies will be attenuated by C8 & C9 so the correction will not be as strong as for frequencies that readily pass through the coupling capacitors. The filter is quite responsive from 2Hz and up.

DC feedback for IC3 is through R14 and R15. At low frequencies the DC feedback is delayed slightly with C10 giving the effect of over correcting the output which helps the filter to operate at the lowest possible frequencies.

AC VOLTAGE MEASUREMENT

When AC voltage measurement of dB measurement is made, the AC voltage at the DVM56 input jack is routed through the front panel function switch to the AC divider R51, R1-R4 on the AC board schematic Figure 7. IC1 is an inverting amplifier with three separate feedback paths controlled with range switching signals from the uP. Ranges of 20V, 200V, and 1000 VAC are provided. Note that IC1 stage gain is 0.1, 0.01 and 0.001 respectively for the three ranges; determined by dividing the value of the feedback resistor by the input resistor R51, R1-R4 or one megohm. Thus the maximum output from IC1 when full input is applied for each range is 2 VAC range. Each range is independently adjustable from the other ranges with controls R8, R10, and R12 for the three ranges.

Range control signals from the uP feed to level shifting transistors TR3 and TR4 which in turn control switch transistors TR2 & TR1 respectively. TR3 or TR4 is turned on when the base is held low with the uP signal, which in turn causes TR2 or TR1 to conduct closing the "switch" for the range selected.

The input to IC1 is AC coupled through C2. However, one DC feedback path to the input is provided so that a lower voltage rating input capacitor can be used. Without DC feedback, the input could float to the DC component of the AC signal being measured. The protection rating on the DVM56 is 2000V DC + peak which would mean there could be up to 2000VDC component. The DC feedback (the feedback network for the 20V range is used) limits the DC across the capacitor to 200 volts.

The AC divider is frequency compensated on each range so that signals up to 100 KHz can be measured. C5, C6, and C7 compensates each of the ranges. C1 and C17 compensates the input resistor R1-R4. The basic action of the input circuit has a tendancy to peak up at the high frequencies so the first 50K, R51, of the input resistor is left uncompensated to flatten out the response.

The output from IC1 goes to switch IC2, which among other things will select the signal for processing from the IC1 output or from the ACC signal input. This selection is controlled by the uP by knowing which position the panel function switch is in. The signal selected by switch IC2 is AC coupled into two different processing circuits, an RMS processing circuit and a peak-to-peak processing circuit.

The signal to the RMS processing circuit is coupled through C11, C12, and R27 to the input of a true RMS processing chip IC3. The output of IC3, pin 8, couples off of the AC board to the A/D board where it can be selected to feed the A/D converter if true RMS measurements are being made. If an average RMS measurement is selected, the 2.2 uF capacitor, C8, connected to pin 6 of RMS processing chip IC3 through a second switch section on IC2, is disconnected leaving only capacitor C13 in the circuit. This changes the output on pin 8 from a pure DC voltage representing the true RMS value of the signal to an absolute value signal i.e. a signal that

would output from a perfect full wave rectifier circuit. Thus the only difference in the circuit between average RMS and true RMS is the capacitor C8. However, since the average value of a sine wave is only 90% of the true RMS value, the uP multiplies the average measured value by 1.11 so the readout is calibrated in RMS, a standard procedure for most multimeters.

A third switch section on IC2 is used to change between the average and true RMS zeroing controls R20 and R21. These controls select ± voltage to feed to resistor divider R22 and R23. The voltage at the junction feeding pin 1 or IC3 is used to zero out accumulated circuit offset and variations. The input offset voltage of IC3 is adjusted for minimum effect with adjustment R49 and R50.

Gain adjustment R27 compensates for R223. R223 caused an approximate 1% increase in output which is trimmed out with R27 for the greatest accuracy.

The true RMS chip, AD536A, is a device supplied by Analog Devices. We have included their sheet on principle of operation for those who desire to understand how this chip performs true RMS measurements. See supplement two.

R24, R26 and CR3, and R3V, R33 and CR6 are protection circuits designed to limit the output voltages from the RMS processing circuit and the peak-to-peak processing circuit from going too high and damaging switch IC4 on the A/D board, Figure 4.

The signal to the peak-to-peak processing circuit is coupled through C9 and C10 to the input of IC4. IC4 and CR4 comprise a negative peak detector. IC5 and CR7 comprise a positive peak detector. The zero adjust R10 compensates for the inherent offset voltages of IC4 and IC5. The negative half cycle of an AC input signal to IC4 will cause the output at pin 6 to go positive causing the capacitor combination C9 and C10 to charge positively on the lower plate of C9 with respect to ground an amount equal to the negative peak. If you were to look at pin 2, IC4 with a DC coupled oscilloscope you would see the full AC signal with the negative peaks just touching ground level.

The positive peak detector IC5 and CR7 charges C17 positive to a level equal to the most positve voltage applied to pin 3 of IC5. Since the most positive voltage is equal to the peak-to-peak level of the input signal (remember the negative peaks are just touching ground level at the input of IC5 through the action of the negative peak detector) the output across C17 is a DC voltage that equals the peak-to-peak level of the input signal. This output, as does the RMS output, couples off of the AC board to the A/D board where it can be selected to feed the A/D converter if P-P measurements are being made.

Peak detectors have an inherent problem in the long holding time that they must exhibit if they are to have any reasonable response at low frequencies. This plus the signal overshooting could easily cause big errors. Resistors R43 and R36 on the outputs of the detectors prevents the outputs from overshooting and charging the capacitors to levels higher than the actual peaks. A quick discharge circuit consisting of R42, CR5, C15, R41, IC6, R46, TR6 and R45 for the negative peak detector and R37, CR8, C16, R47, IC6, R38, TR7, and R35 for the positive peak detector operate to change the long time constant to a very short time constant so the holding capacitors discharge quickly, if the signal should suddenly reduce in level or when changing to a lower voltage test.

Looking at the quick discharge circuit for the negative peak, a second detection system is used, R42, CR5, and C15 which controls a NOR gate, IC6, connected as an inverter. When a signal is present the inverter biases off TR6 so that the time constant for the peak detector is long with R44 a 22 megohm resistor. When a signal isn't

present or if it suddenly changes to a lower level the fast acting second detection system will cause the inverter to change states and turn TR6 on. When TR6 conducts the peak holding capacitor C9 and C10 is quickly discharged through R45.

The quick discharge circuit for the positive peak detector works in the same way. A second NOR gate in IC6 is used. Both quick discharge circuits work when the signal has been removed or reduced for one half second or more.

OHMS MEASUREMENT

When an ohms measurement is made, the positive input jack connects directly to the input on the ohms board through two two amp fuses on the rear panel, the front panel function switch, and a 1/16 amp fuse on the rear panel to the ohms board input, R38, etc., on the ohms and current adjust board schematic, Figure 8. Ohms measurements are made by passing a predetermined constant current through the unknown resistor and then measuring the voltage developed across the resistor. This results in a linear scale since E=IR. One problem using linear scales to measure ohms, is that one scale has to be provided for each decade of measurement. This condition isn't too serious with an autoranging meter, but is more cumbersome in a manual controlled DVM.

Eleven different ohms ranges are provided in the DVM56, five for low power ohms, six for high power ohms. All low power ohms measurements use the 0.2V full scale sensitivity of the A/D converter whereas all high power ohms measurements use the 2V full scale sensitivity.

Low power ranges provided are 0-200 ohms, 2K, 20K, 200K and 2 megohm. Therefore, the constant currents necessary to develop 0.2V full scale are 1mA, 0.1mA, 10uA, 1.0uA and 0.1uA respectively. The high power ranges provided are 0-2K, 20K, 200K, 2 Meg, 20 Meg and 100 Meg and the constant currents necessary to develop 2V full scale are 1mA, 100uA, 10uA, 1uA, 0.1uA and 0.1uA respectively. Note that the 100 meg range will develop 10V across a 100 megohm resistor but the uP senses when the normal output is greater than 2V and then instruct the A/D board to select a second output from the ohms board which is one tenth the normal output and is taken from the junction of R20 and R21. Normal output is through R17 from the buffer IC3.

The constant current that feeds through the unknown resistor is generated by placing either 1VDC or 10VDC across one of a series of internal standard resistors. The constant current generating circuit is allowed to float above ground so that the voltage that is developed across the unknown resistor during measurement does not change the standard current source.

This is accomplished with amplifier IC2, Figure 8. The series of standard resistors are R10, R11, and R12 and R13. The unknown resistor is connected from the bottom of the standard resistor used depending on range, to ground. Visualize the test leads shorted, i.e., unknown resistor equals zero. Then a constant current from TR1 of 125 uA will flow through the IC2 feedback network fo R6 or R6 parallel with R7 and R8, depending on the range and develop a positive 1V or 10V at the putput of IC2 with respect to the + input of IC2. Since the leads are shorted the 1V or 10V could be

measured with respect to ground because the input of IC2 would be grounded. The output of IC2 is positive, therefore, electron flow will be from ground through the standard resistor to the IC2 output. Now let's visualize a reisitor being measured instead of a short. The electron flow will generate a positive voltage across the resistor with respect to ground. The + input of IC2 will be raised by the amount of voltage developed across the resistor being measured but the negative input of IC2 will follow this change also. The collector voltage of TR1 obviously increases, but TR1 collector current does not--it remains at 125 uA, therefore, the voltage developed at the output of IC2 across the IC2 feedback resistor(s) remains at 1V or 10V and consequently the voltage across the standard resistor also remains the same, 1V or 10V and, of course, the current through the standard resistor to the input jack didn't change even though the voltage at the jack increased.

Notice that the total current flowing through the internal standard resistor has to also flow through the resistor being measured. The + inputs on IC2 and IC3 are FET inputs with very high input impedance and have negligible leakage current. Likewise, switch ICIC has very low leakage and should not affect the measurement accuracy.

TR1 is a constant current stage that operates from a very stable temperature compensated zener diode, CR3. The constant voltage on the base of TR1 reflects across the emitter resistors R2 and R3 that generate the 125 uA constant output current. CR1 and CR2 compensate TR1 for temperature variations.

Since the ohms circuit floats, except the voltage developed across the measured resistor is with respect to ground, a good signal ground is also needed on the CR3 zener reference source to prevent noise from affecting ohms accuracy. Therefore, a separate ground is used for the zener diode, which connects it directly back to the A/D ground on the A/D board.

Three standard resistors 1K, 100K, and 10 mehohm and two standard voltages 1V and 10V are used to generate the constant measuring currents needed. The 10 megohm resistor provides 0.1 uA and 1 uA the 100K resistor provides 10uA and 100 uA and the 1K resistor provides 1mA. The currents needed for each high and low power ohms ranges where discussed above. The uP automatically selects the proper current for each range through three control lines to the ohms board.

The 1K standard resistor R10 is selected when TR5 conducts closing relay L1. The 100K standard resistor is selected when TR4 conducts closing switch IC1B. The 10 mehohm standard resistor is selected when both TR4 and TR5 are cut off.

Standard voltage of 1V is selected when TR2 is cut off. The TR2 collector goes high closing switch ICIA which parallels R7 and R8 with R6. Standard voltage of 10V is selected when TR2 conducts.

When the uP senses an overrange on a resistor being measured it will reduce the current by one magnitude and continue to do so in steps until a range is reached where the resistor will read. If the uP senses a count of less than 1800 (approximately 9% of scale), it will increase the current by one magnitude until a range is reached where the count is above 1800 or when the lowest range is reached.

TR3 and switch ICIC provides an internal zero circuit that zeros out the IC3 offset voltage automatically whenever the ohms function is selected. The series switch opens and the ground switch closes to record the offset voltage, which then is subtracted from the reading. This zero circuit should not be confused with the ohms zero switch on the front panel. That is a uP software function that records the internal and lead resistance and subtracts the amount from the reading when the ohms zero button is pushed.

CURRENT MEASUREMENT

When a DC or AC current measurement is being made, the current is routed through shunts R18 and R19 on the power supply board, schematic Figure 9. Heavy duty 3A rectifiers CR11 and CR12 prevent the voltage developed across the shunts from exceeding +1V. Relay K1 is closed in the 2A range when TR6 is cut off to reduce the voltage burden to the circuit being measured. Two outputs are generated from the shunts, one for the 20mA range and one for the 2A range. These connect directly to calibration networks located on the ohms and current adjust board, see Figure 8.

R35 and R36, Figure 8, parallel the 2A shunt. The DC voltage picked off by R35 is proportional to the DC current through the 2A shunt. Resistors R33, R34, R35, and R36 parallel the 20mA shunt, and the DC voltage picked off by R33 is proportional to the current through the 20mA shunt. One of these voltages is selected by the uP through the action of switch IC4A, depending on the range. IC4A is a single pole two position switch that closes between pins 13 and 14 when the control line pin 11 is high and closes between pins 12 and 14 when the control line is low.

The output from IC4A couples off of the ohms board to the A/D board where it can be selected to feed the A/D converter if DC current is being measured. If AC current is being measured, the output from IC4A is AC coupled to amplifier IC5 through C4. DC current measurement uses the 0.2V A/D range and since the same current shunts are used for both DC and AC it is necessary to amplify the AC current signal by 10 to match the 2V A/D range that is used for AC voltage measurement. IC5 amplifies the AC voltage at its input that is proportional to the AC current being measured by 10 times so that the output can be fed directly to the AC true RMS voltage processing circuit on the AC board, Figure 7. R37, Figure 8 is an AC current calibration adjustment. This adjustment is dependent on the DCC adjustment being correct and also on the AC true RMS voltage gain adjustment being correct.

POWER SUPPLY

The power supply, see Figure 9, is fairly straight forward. The transformer primary receives voltage from the line through front panel on-off switch. Two transformer secondaries are used. One supplies a bridge circuit CR7-10 which feeds +5V regulator IC3, which feeds all of the signal processing PC boards. It also provides unregulated +8V for use by the digital displays.

A second tapped secondary provides voltages to positive and negative full wave rectifiers CR1 and CR2, and CR5 and CR6.

A +15 volt regulator circuit consists of TR1, TR2, IC1, CR3, and other associated parts. IC1 is a sensing amplifier that controls pass transistor TR2. Overload protection is accomplished by TR1 pulling the input of IC1 high when load currents greater than 120 mA are drawn, which drops the output voltage to a safe level. Cr3 is a temperature compensated reference diode so that

once the +15V output is set with R6, it will stay accurate with temperature and provide a wider temperature range of accurate operation. R1 is a start up resistor that will get the circuit operating. Once going, the bulk of the zener current comes through R8. Diode CR4 is used in the base of TR2, to insure that TR2 can be shut down completely, because the TL018 output does not go all the way to the negative rail.

The -12V regulator is referenced to the +15 volt output through divider R12 and R14 so that it will track the +15V. IC2 is a sensing amplifier that keeps the base of TR5 at approximately -12.6V to give -12 volts output at the emitter. The -12V supply is protected by TR5 saturating.

Two additional outputs +7.5V and -7.5V are provided for operation of the DVM56 circuits. TR3 provides +7.5V through emitter follower action of a voltage divider to +15V on the base and TR4 provides -7.5V through emitter follower action of a voltage divider to -12V on the base. Both TR3 and TR4 are protected against shorts by the high base circuit resistance.

DVM 56 TROUBLE SHOOTING

GENERAL TROUBLE SHOOTING GUIDE

Finding a problem in a defective DVM56 could be very difficult if one does not have a good understanding of the circuitry and how the uP controls everything that happens when a measurement is made. If you do not have a good understanding of circuit operation, read the circuit description again and study signal flow.

The troubles that are discussed in this section were troubles that actually existed and were found in the Stage III and Stage IV units. These problems were in addition to the many shorts that were found. We will not be discussing shorts, and associated symtoms, however, because we honestly do not expect to see many problems involving shorts. Automatic testing equipment (ATE) will be installed by the time the DVM56 is run in production, and shorts and wrong value components will be weeded out before each individual PC board, is installed in a unit.

Some general procedures should be used when tracking down a trouble in a defective unit. The first step that one should do is make certain that all of the supply voltages are correct. Remember that each output in the power supply is self protected, so one or more of the output voltages could be low from an overload, without any components getting hot or burned.

Next, you should be sure that all of the fuses are good. If the Ohms function appears to be working all of the fuses can be checked at the same time just by shorting the test leads and looking for a "zero" reading. "Zero" will read about 9.7 ohms until the zero ohms button is pushed. If you do get a "zero" all of the fuses are good, because they are all in series on ohms. If you do not get a "zero", use the black test lead and short directly to the input on the ohms board work towards the + input jack until a defective fuse is found.

Erratic operation is difficult to find. Two causes that were discovered were: 1. a loose strand on one of the stranded wires going to the function switch intermittantly touching the frame of the switch and : 2. the input spark gap was not backed off enough causing erratic ohms.

Before getting locked into a particular board that you start to dissect looking for a problem, be sure you have the right board. Some problems can be decieving. Several times when only one type of board was being tested, i.e., a good operating unit was used and only the particular board under test was changed each time, a problem might appear to be somewhere else other than on the board being tested. Try to pinpoint all of the symptoms before settling on a particular circuit.

Without any input signal to the DVM56 learn where the decimal should be, which range light is on and the reading on the display for each function as you switch from AC current all the way through to programmable DB. This will tell a lot about general operation of the UP; if it is reading the function switch correctly, and if it is performing with the A/D to give a display.

Proper ranging may be a little more difficult to ascertain, because various levels of input signals are required to activate each range for each function. If ranging is suspect the necessary currents, resistance and AC and DC volts should be fed in and the range lines measured for the proper lows and highs (0's and 1's) called out on the range chart and also shown on each schematic. Another helpful hint is to lock the range with the lock button. Remove the input. Then while observing the range lines, unlock the range and observe what happens. The ranging should revert back to the zero signal condition.

CONTROLLER PC BOARD AND DISPLAY

If abnormal operation is apparent in several functions when rotating the function switch through all of it's positions, it is likely that the control board or the display board is at fault. Since the control board is easily replaced, this should be done with a known good board and the functions rechecked. If operation is restored to normal, it's obvious that the original control board is defective. If normal operation isn't just current, ohms, DC volts, or AC volts functions that are malfunctioning, in which case the problem could be on one of the other processing boards.

Display board problems are relatively easy to pinpoint because each segment of all displays are driven in parallel from a different source, so if a segment is out in one display it's out in all and, of course, each display has it's own driver. Display board problems were not very prevalent in stage III and IV units.

Some problems that were found on the controller board involved the uP. On three separate occasions average AC volts would not function - the system would maintain the reading from the previous function, i.e., P-P volts or true RMS volts. Replacing the uP corrected the problem. Extra pull up resistors were added on some boards, which appeared to help. New boards will have pull-up resistors.

Another uP was the cause of a "noisy" zero on DCV. DCV is supposed to have an auto zero when switching to the DCV function. This didn't seem to be at fault, however. Somehow noise was getting into the reading through the uP. Another uP had no paint over the window covering the chip and device appeared particularly noisy when flourescent light was allowed to contact the chip.

Very few problems were encountered with the peak and null circuitry. One interesting problem, was a slow acting low indication, i.e., a slow low. It was caused by the feedback transistor on the low side not operating properly.

Once you have determined that the general system is operating and the problem is more specific, involving only a single function, the individual suspect boards can be easily trouble shot with the help of an extension board. This takes the board out of the cage making both sides accessable for servicing.

Some of the specific problems that were found in Stage III and IV units are reported below. Once again, many of the problems encountered were caused by shorts on the boards which are not reported here, because with ATE this type of problem should no longer be a factor.

A/D BOARD

Several units displayed a problem where the reading gradually and continually changed - normally noted in DC volts. Always be sure that DC volts works properly before testing other functions, because DCV measurements are made by tapping off of a divider and feeding directly to the A/D chip. The drifting reading was caused by an open relay, L 1. With the relay open the A/D loses its ground reference and the input will float up or down depending on the prevalent leakage currents.

Another problem that took a while to find was that the 2KV range for DC voltage could not be calibrated - it was always high. The divider resistors all checked good. The problem turned out to be that contact on relay L 1 were stuck closed, effectively shunting out part of the DC divider, R6 and R7 when in the 2KV range. It didn't bother the lower ranges because the contacts are supposed to be closed. Here is a case where locking the range in the 2KV range would help to hold the troublesome condition for easier trouble shooting.

A strange problem showed up when calibrating the 20 volt and 2KV DC ranges. The normal procedure was followed, calibrating the A/D first then feeding in 10VDC to adjust the 20 volt range, then feeding in 1000 VDC to adjust the 2KV range. When 10V was again fed in it was found that the reading had changed significantly and was out of spec. Three or four units had this problem. The first few were corrected by changing what appeared to be a noisy divider resistor - one of the 2.7 Meg resistors. The last unit was corrected just by resoldering all the divider resistors. Not sure what the exact problem is with the resistor or how prevalent this condition will be as more DVM56's are run, but reheating somehow improved the resistor contact.

Many of the problems encountered on the A/D board were a noisy or, erratic zero on DCV. As explained, many of these were caused by shorts, but a direct short isn't necessary to cause a problem. The A/D input is high impedance and leakage paths through solder flux etc., can easily be the cause of the problem. Also the interface of the problem by grounding the input of the A/D while looking for a stable zero reading. If a stable zero reading can be obtained with the A/D input shorted, the leakage or problem is obviously at the input circuitry. If not, the problem is in the interconnect circuitry.

A/D with the µP must be right. One can often isolate the source of the

AC BOARD

The AC board converts AC voltage to DC voltage through two different processor circuits, an RMS circuit and a peak to peak circuit. Both processing circuits use a common in put active divider. If ranging is correct for peak to peak volts which is generally checked first per the alignment procedure, it should also be correct for RMS volts. Both circuits are straight forward without too much that can go wrong.

About the only problems found with the P-P circuits was poor lineanity when the - 3 volt supply wasn't negative enough on stage III units and noisy operation when measuring low level voltages. The - 3 volt supply was changed to be more negative during the stage III and PP lineanty was not a problem on Stage IV units. Be sure this supply is checked first, however if you should experience a unit with poor lineanty on peak to peak measurements.

Erratic or noisy operation when making a low level PP measurement could be caused by the quick discharge circuit detectors not holding enough charge. The ± peak time constants will change between long and short creating an erratic output. The timing components in these circuits should be checked for accuracy.

RMS problems seemed more severe in Stage III and IV units, than PP problems, but not sure why, because less circuitry is involved. In stage III we did find a whole batch of RMS chips that gave poor lineanty. Actually there isn't too much else that can cause poor RMS lineanity, so if you should experience this problem, it's probably the RMS chip at fault, IC3.

One interesting problem was a true RMS reading that was only about 90% of what it should have been. A little thought directed attention to the 2.2 UF filter cap, C8. Sure enough it was open. Remember, without the filter cap the output from the RMS chip is like a full wave rectified output so the A/D will only respond to the average value instead of the RMS value. Average of a sine wave, of course,in 90% of the RMS value.

Another problem found and corrected in Stage III units was high level measurements (900 VAC) going out of spec. This was caused by switch transistor, TR2, not turned on hard enough. R15 was changed from 4.7K to 3.3K which helped to bring the readings back into spec. However, there is still some problem with ACV readings being too close to limits which may or may not involve this stage (TR2). Engineering is currently working on this problem.

In several units it was found that high frequency response rolled off faster than it should have. The 50K and 200K resistors at the input were interchanged.

OHMS BOARD

The ohms board develops a DC output voltage proportional to the value of the resistor being measured. Problems in Stage IV units were many. One involving a large number of units was the inability to calibrate ohms and keep all ranges in spec. Those that could be calibrated were on the edge. The culprit appeared to be a leaky switch ICIC. The ohms measuring circuit is a very high impedance circuit and it doesn't take much leakage current to upset a reading during measurement of high value resistors. ICIC switch leakage could not be measured but changing the chip solved the calibration problem on several units - at least four. This is a CMOS chip subject to handling damage. Checking with personnel in stock room and production did not reveal any mishandling of the part. The symptom for this condition is that after following normal calibration procedures the 1K low ohms reading will be high and the 100 ohm reading will be low.

Remember that all ohms ranges result from using one of two standard voltages and one of three standard resistors. The standard voltages, IVDC and 10VDC can be easily checked by shorting the test leads. First lock the appropriate ranges that will give you first 10VDC out and then 1.0VDC out. The 10VDC has to be set first since the 1.0VDC is dependent on the 10VDC setting. A 4½ digit meter should be used. Being sure the standard voltages are right reduces the problem area.

The 1K and 10Meg ohm standard resistors can be measured with an ohmeter.

There wasn't any trouble experienced with DC or AC current measurement. Of course there isn't much that can go wrong either. Do keep in mind that AC current uses the same shunts as DC, and that the develpped voltage is amplified 10 times, then processed in the true RMS circuit on the AC board. DC output feeds directly to the A/D board.

POWER SUPPLY BOARD

The power supply was relatively trouble free. It is also straight forward and normal trouble shooting techniques should be used.

In conclusion, the troubles reported here were those found in Stage III and IV units, and while they covered a fairly broad area, do not necessarily include all of the things that can go wrong. We will add to this section after Stage V completion and after the first production run. However, what we have tried to point out, is that like anything else, if one can isolate the likely trouble area through simple tests and a good understanding of function and of circuit operation, then he can quickly become a qualified repairman for the DVM56.

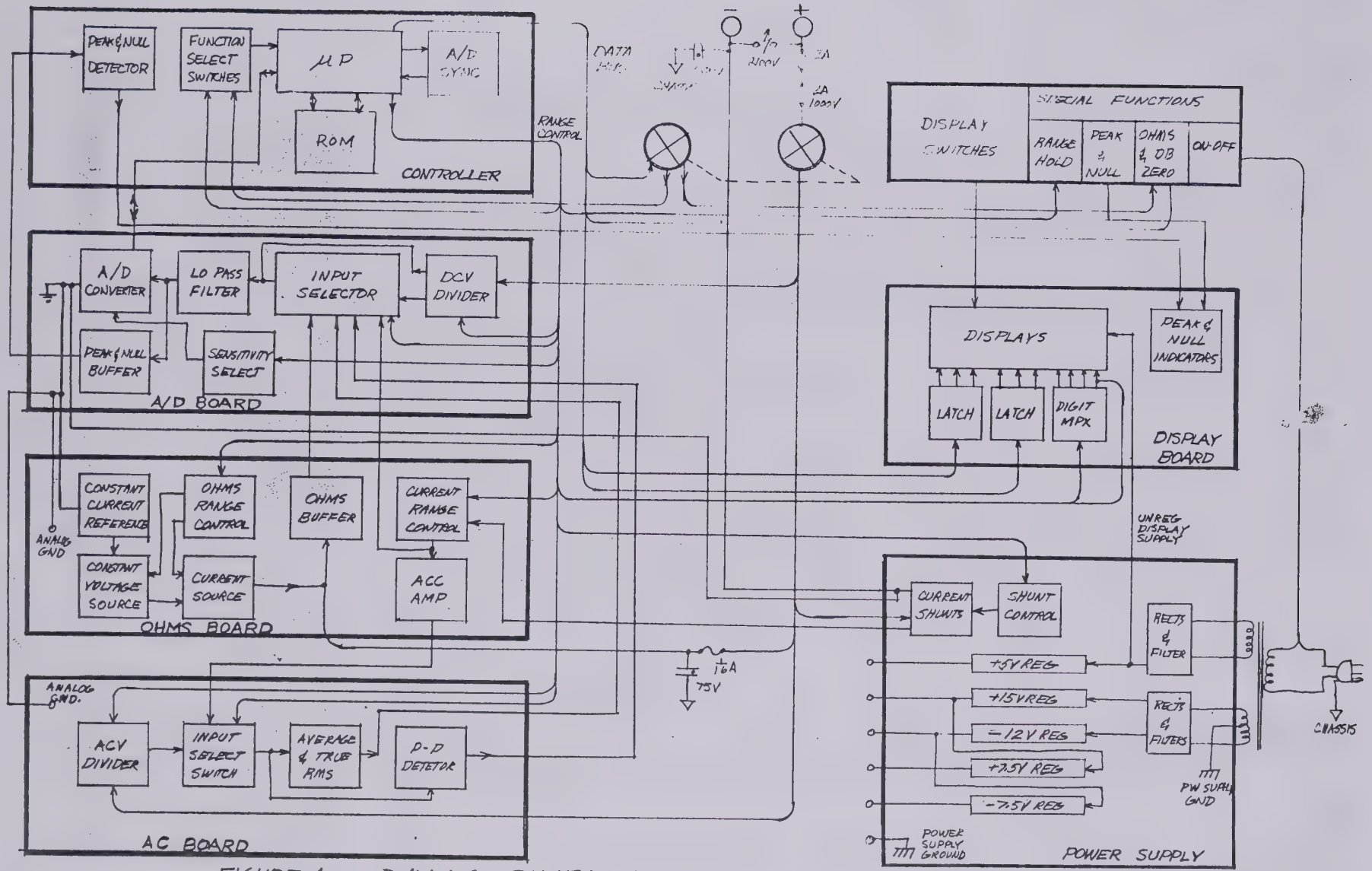
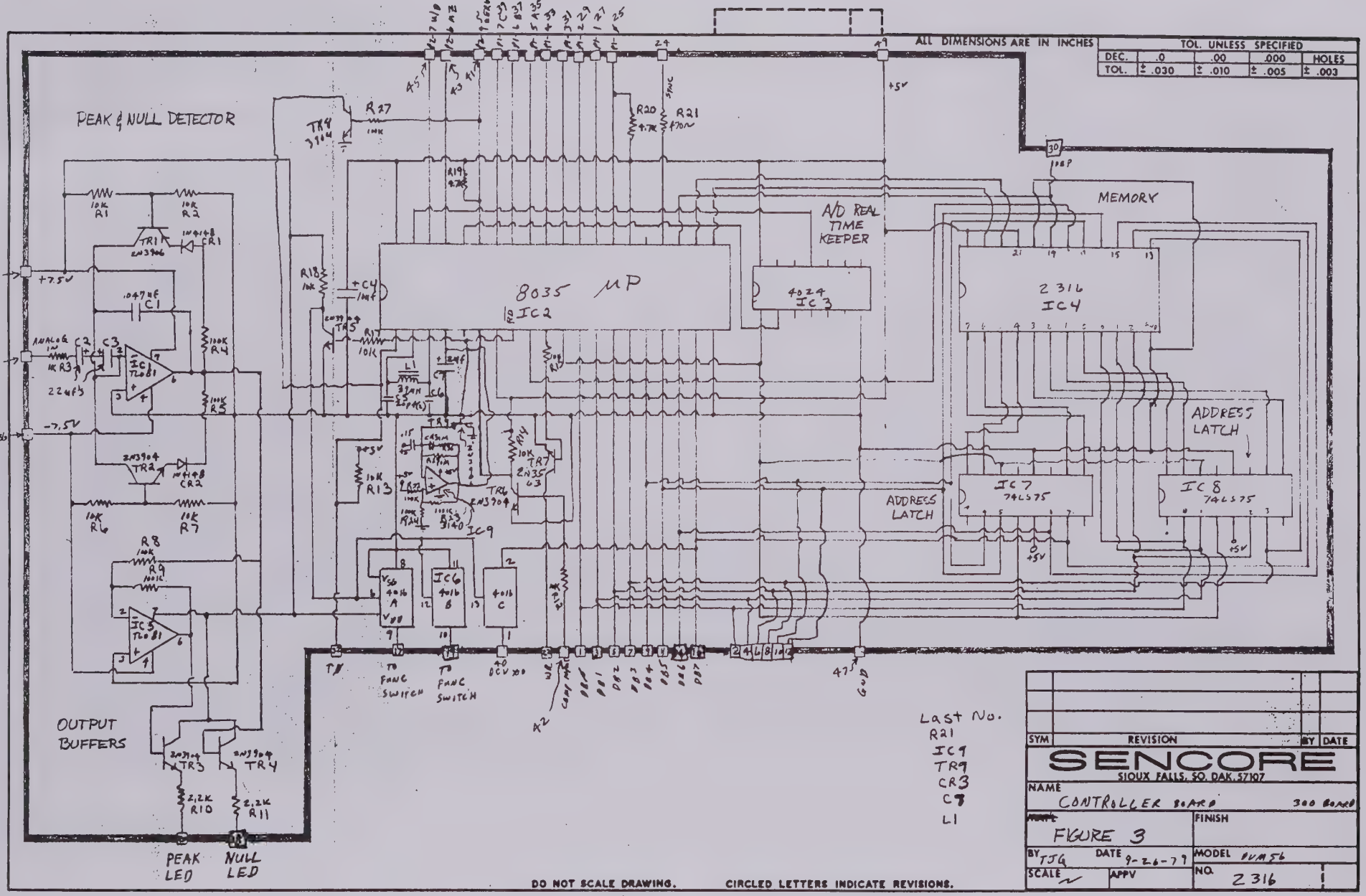


FIGURE 1, DVM 56 SIMPLIFIED BLOCK DIAGRAM


ALL DIMENSIONS ARE IN INCHES
TOL. UNLESS SPECIFIED
DEC. .0 .00 .000 HOLES
TOL. ± .030 ± .010 ± .005 ± .003
PEAK & NULL DETECTOR
8035 μP
IC2
A/D REAL TIME KEEPER
4024 IC3
MEMORY
2316 IC4
ADDRESS LATCH
IC7 74LS75
IC8 74LS75
OUTPUT BUFFERS
PEAK LED
NULL LED
+7.5V
-7.5V
+5V
GND
TO FANC SWITCH
TO FANC SWITCH
Last No.
R21
IC9
TR9
CR3
C9
L1
SYM REVISION BY DATE
SENCORE
SIOUX FALLS, SO. DAK. 57107
NAME CONTROLLER BOARD 300 BOARD
FIGURE 3
FINISH
BY TJG DATE 9-26-79
MODEL PUM56
SCALE APPV
NO. 2316
DO NOT SCALE DRAWING.
CIRCLED LETTERS INDICATE REVISIONS.

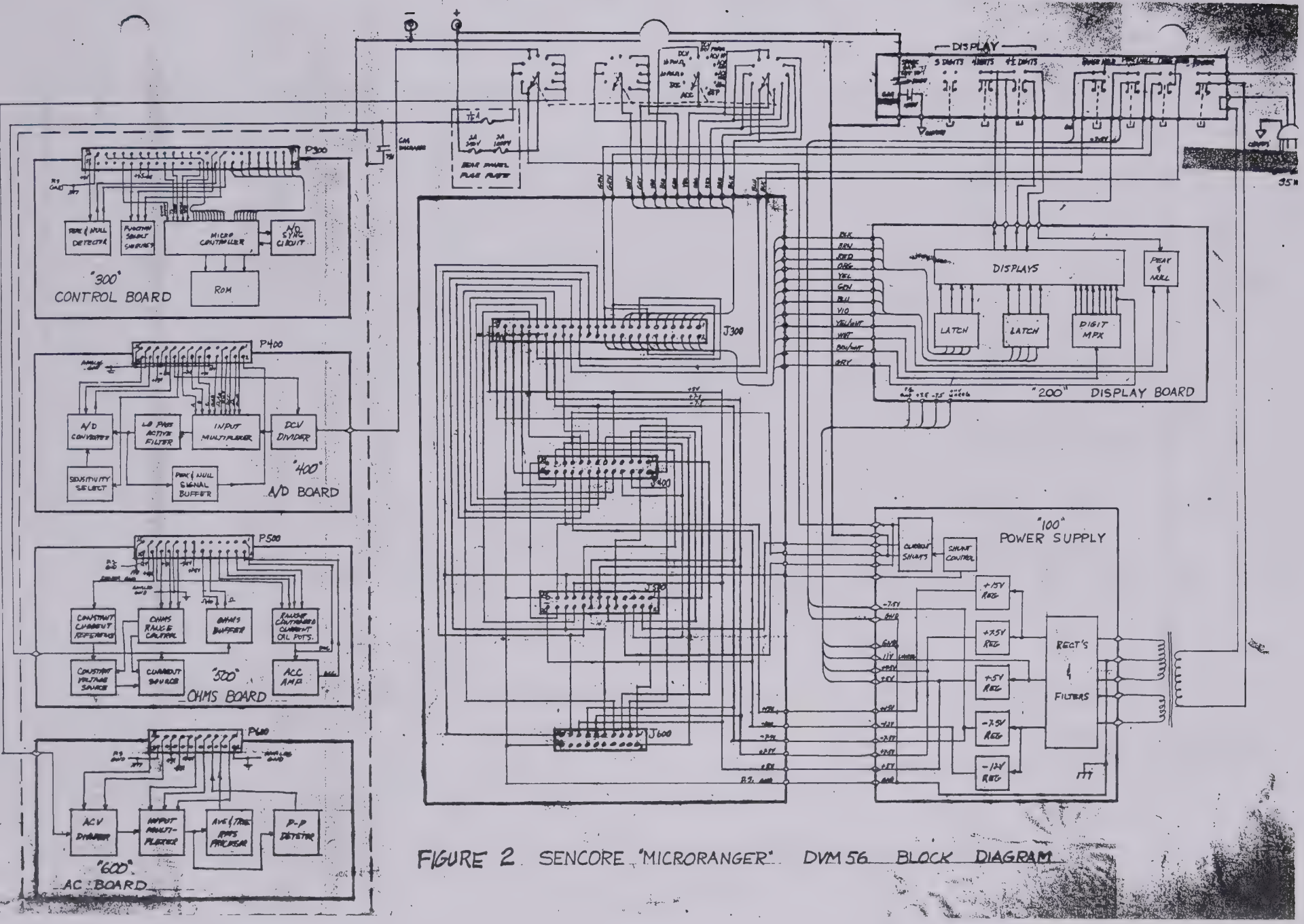
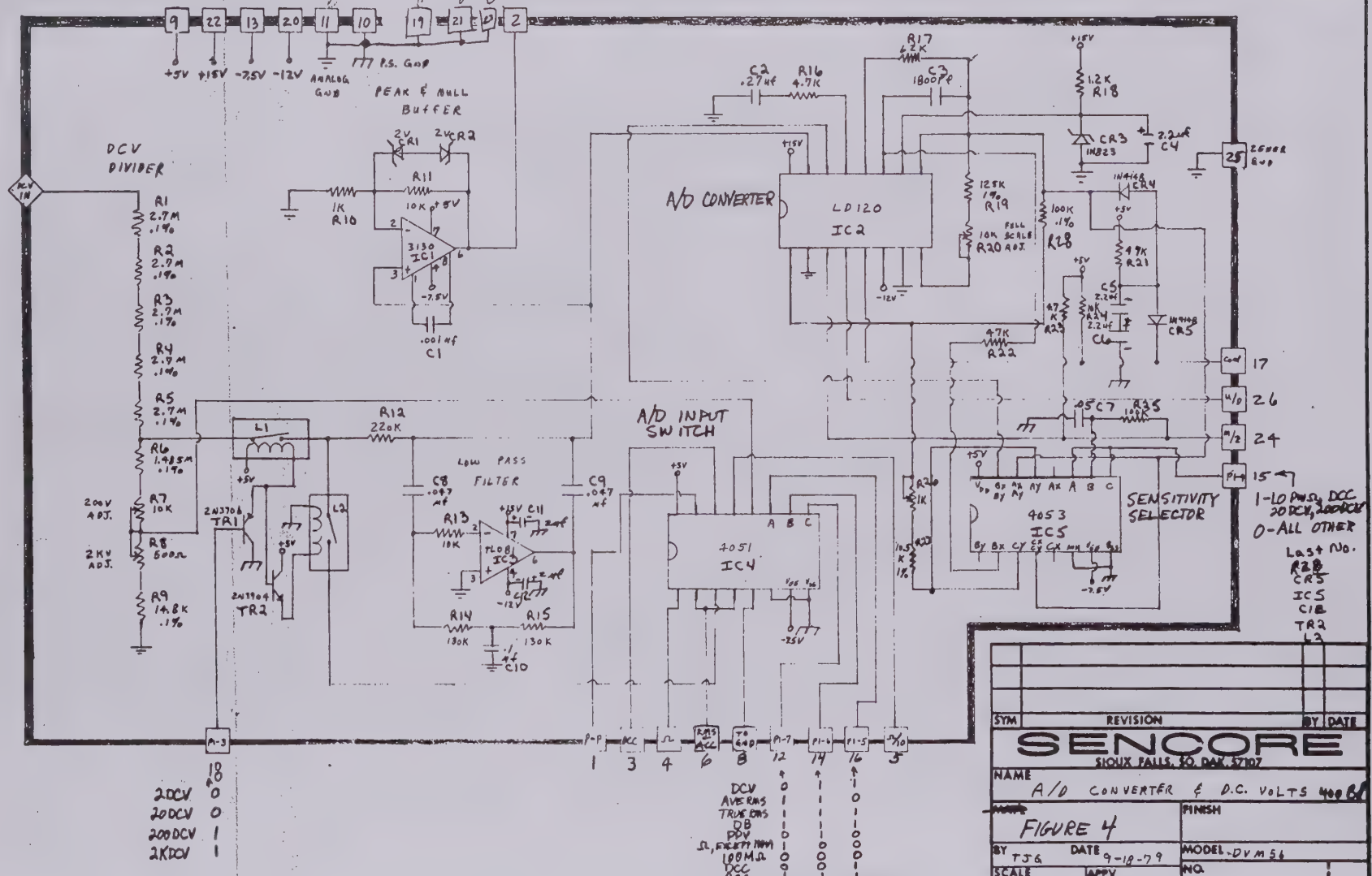


FIGURE 2 SENCORE "MICRORANGER" DVM 56 BLOCK DIAGRAM

ALL DIMENSIONS ARE IN INCHES

TOL. UNLESS SPECIFIED				
DEC.	.0	.00	.000	HOLES
TOL.	± .030	± .010	± .005	± .003



DO NOT SCALE DRAWING. CIRCLED LETTERS INDICATE REVISIONS.

SYM	REVISION	BY	DATE

SENCORE
SIOUX FALLS, S.D. DAK. 57107

NAME A/D CONVERTER & D.C. VOLTS 400 B

FIGURE 4

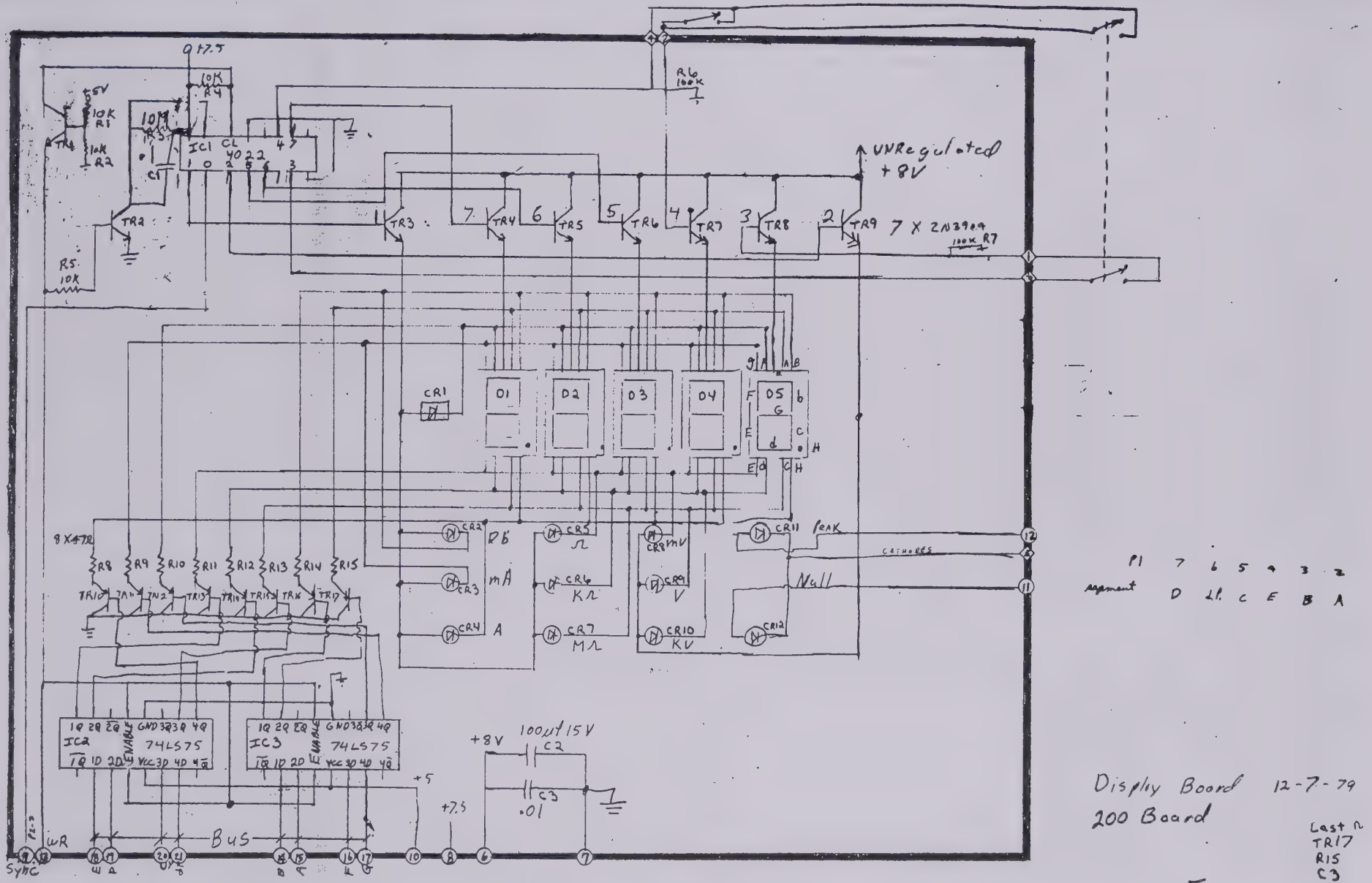
FINISH

BY TJG DATE 9-18-79

MODEL DVM54

SCALE 2/1 APPV

NO.


Q+7.5
10K R4
5V
10K R1
10M R3
10K R2
IC1 CL 4022
C1
TR2
R5 10K
R6 100K
UNRegulated +8V
TR3
TR4
TR5
TR6
TR7
TR8
TR9
7 X 2N3904
100K R7
CR1
D1
D2
D3
D4
D5
8 X 470
R8
R9
R10
R11
R12
R13
R14
R15
TR10
TR11
TR12
TR13
TR14
TR15
TR16
TR17
CR2
CR3
CR4
CR5
CR6
CR7
CR8
CR9
CR10
CR11
CR12
DB
mA
A
KΩ
MΩ
mV
V
KV
Peak
Null
CATHODES
P1 7 6 5 4 3 2
segment D DP C E B A
IC2 74LS75
IC3 74LS75
ENABLE
+5
+7.5
+8V
100µf 15V
C2
C3 .01
WR
BUS
Sync
Display Board 12-7-79
200 Board
FIGURE 5
Last ∩
TR17
R15
C3
D5
IC3
CR12

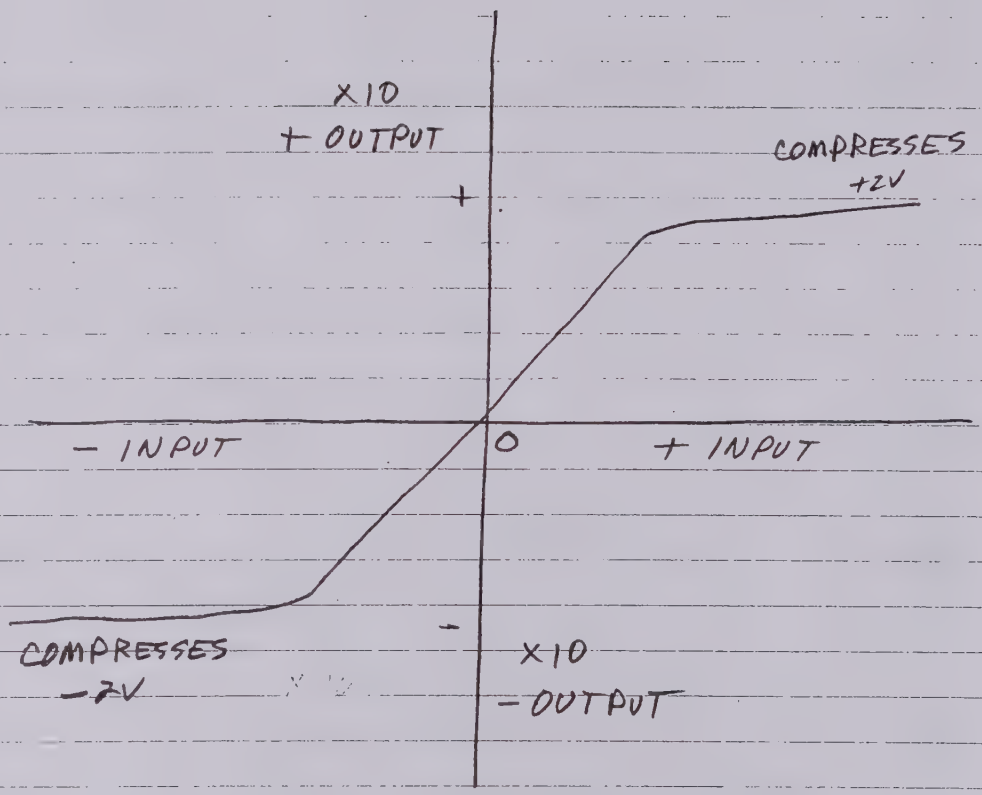
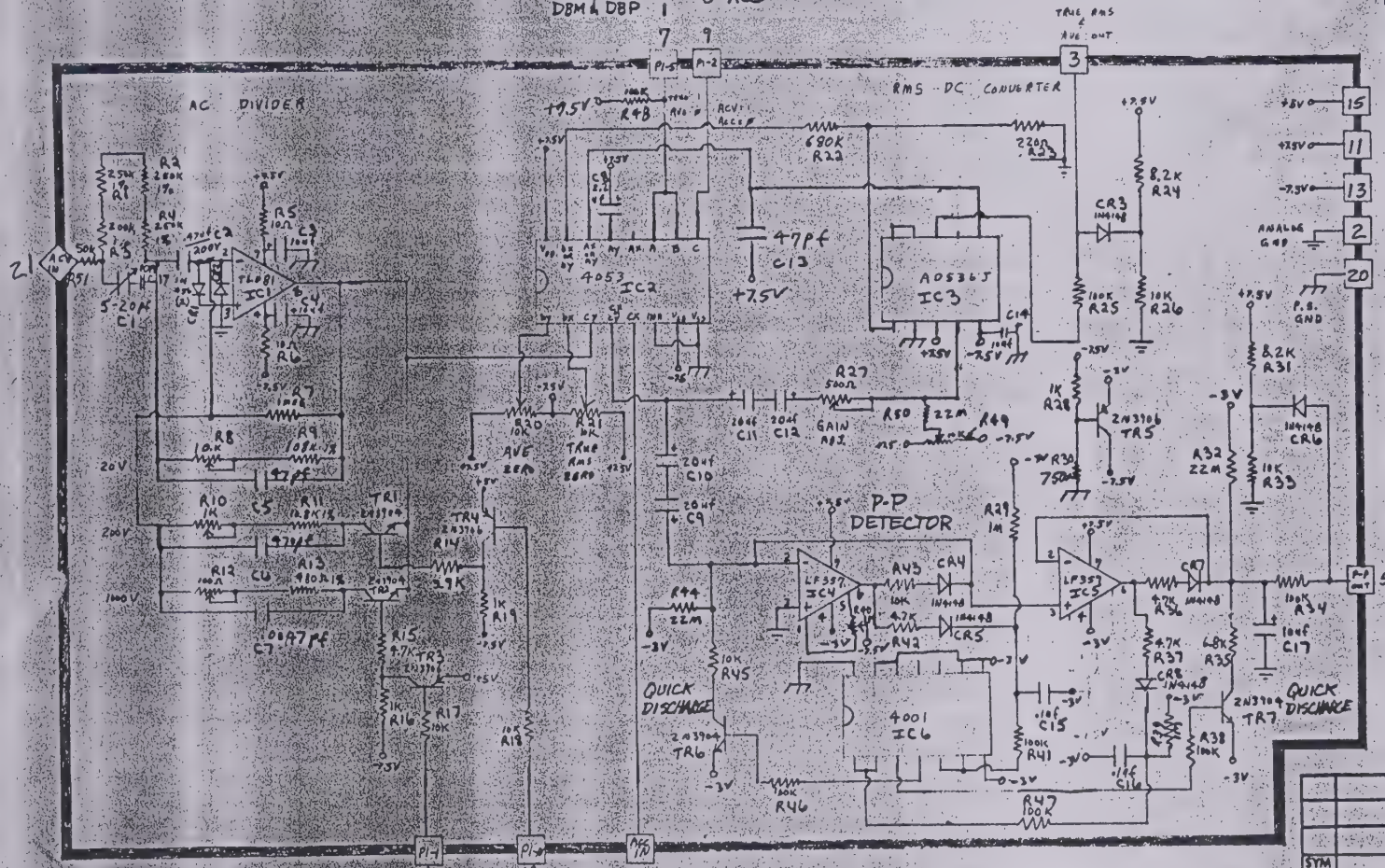


FIGURE 6, RESPONSE CURVE OF PEAK AND NULL BUFFER AMPLIFIER

AVE RMS 0 1 ALL ACV
TRUE RMS 1 0 ACC
DBM & DBP 1

ALL DIMENSIONS ARE IN INCHES

TOL UNLESS SPECIFIED				
DEC.	.0	.00	.000	HOLES
TOL.	± .030	± .010	± .005	± .003



Last No.
R53
C18
CR8
IC6
TR7

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SYM	REVISION	BY	DA

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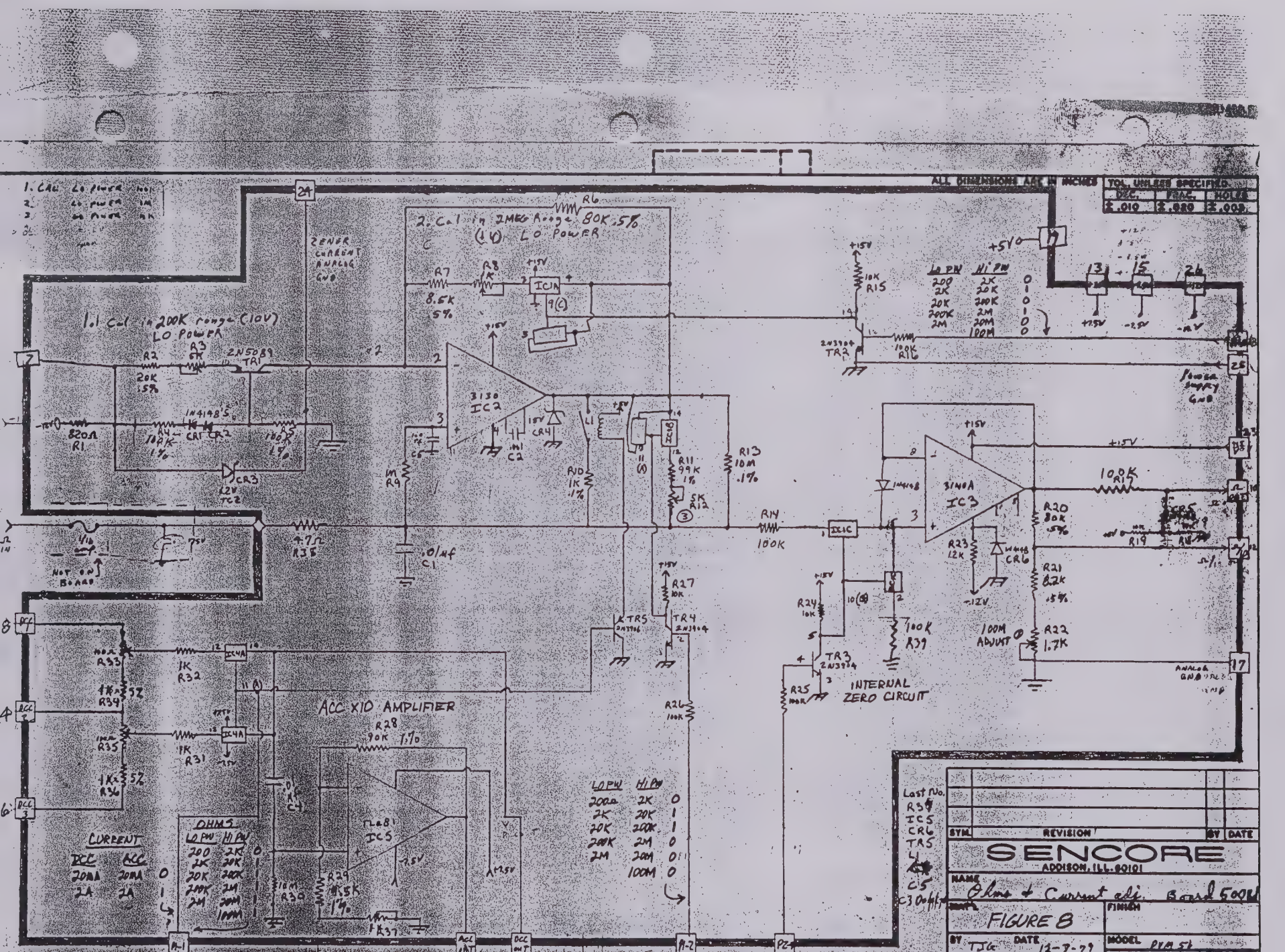
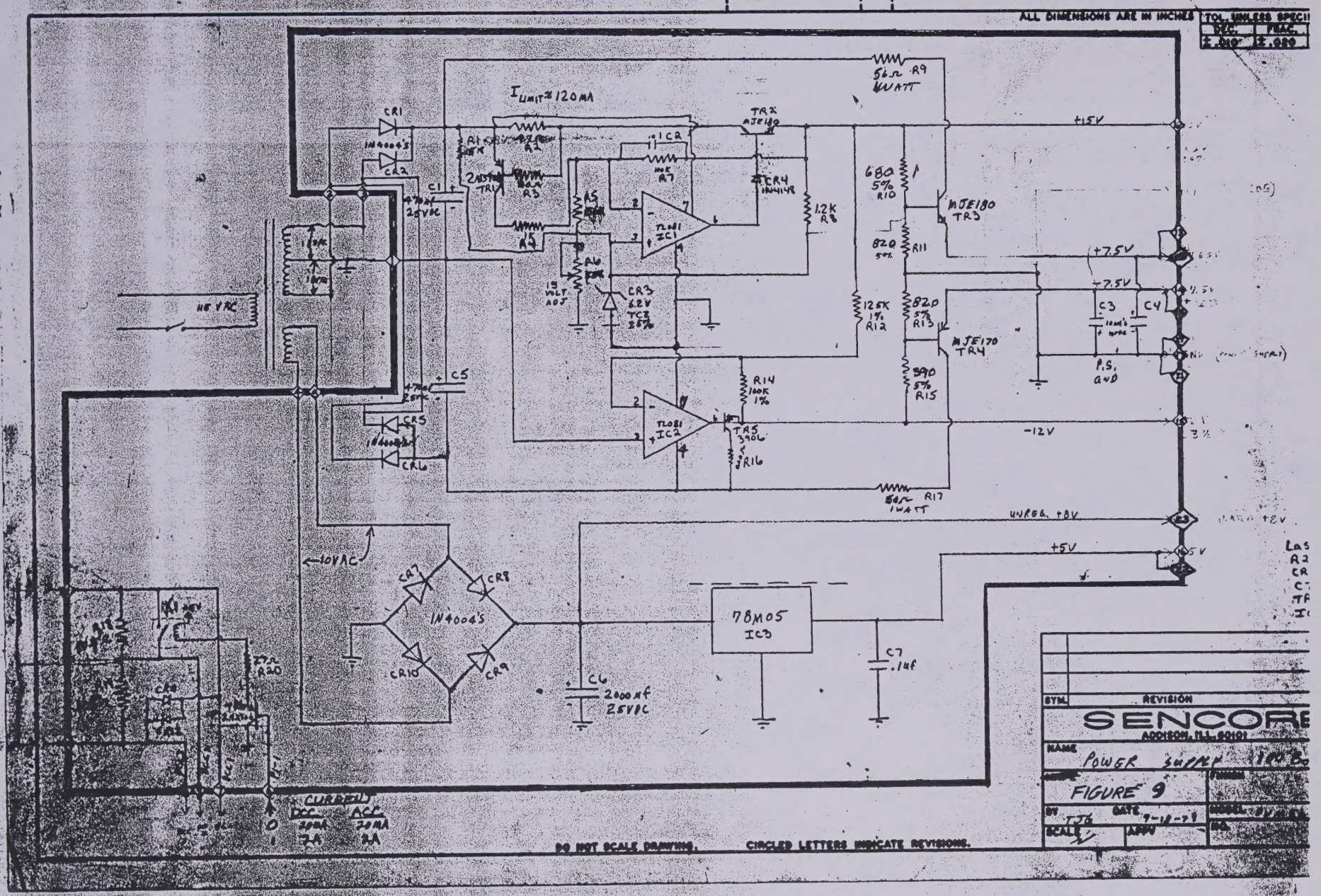
NAME AC DIVIDER, TRUE & AVE RMS, P-P DETECTOR 68
FIGURE 7
FINISH
BY TJG DATE 12-7-77
MODEL DVM 68
SCALE APPV
NO.


ALL DIMENSIONS ARE IN INCHES
TOL. UNLESS SPECIFIED
1. CAL LO POWER
2. Cal in 2MEG Range 80K 5%
(10) LO POWER
1.1 Cal in 200K range (10V)
LO POWER
ZENER CURRENT ANALOG GND
R1 820Ω
R2 20K 5%
R3 5K
2N5089 TR1
1N4148's
CR1 CR2
CR3 12V TC2
R4 10K 1%
R5 160 1%
R6
R7 8.5K 5%
R8 1K
IC1A
IC1B
IC1C
3130 IC2
CR4
C2
C6
R9 1M
R10 1K 1%
R11 99K 1%
R12 5K
R13 10M .1%
R14 100K
C1 .01μf
R35 9.7Ω
NOT ON BOARD
3140A IC3
R15 10K
R16 100K
TR2 2N3904
R17 10.0K
R18 10K
R19
R20 80K .5%
R21 8.2K 5%
R22 1.7K
100M ADJUST
R23 12K
CR6
R24 10K
R25 100K
TR3 2N3904
R26 100K
R27 10K
TR4 2N3904
TR5 2N3906
R39 100K
INTERNAL ZERO CIRCUIT
ACC X10 AMPLIFIER
R28 90K 1%
R29 1.5K 1%
R30 10M
R31 1K
R32 1K
R33 100K
R34 1K 5%
R35 1K
R36 1K 5%
R37 1K
IC4A
IC5 TL081
C3 .01μf
C4 .33μf
C5 .0047μf
CURRENT
DCC 20mA 2A
ACC 20mA 2A
OHMS
LO PW HI PW
200Ω 2K 0
2K 20K 1
20K 200K 1
200K 2M 1
2M 20M 1
100M 1
LO PW HI PW
200Ω 2K 0
2K 20K 1
20K 200K 1
200K 2M 0
2M 20M 0
100M 0
LO PW HI PW
200Ω 2K 0
2K 20K 1
20K 200K 0
200K 2M 1
2M 20M 0
100M 0
+15V
+5V
+12V
-12V
+7.5V
-2.5V
-4V
Power Supply Gnd
Analog Gnd
Last No.
R39
IC5
CR6
TR5
L1
C5 .0047μf
SYM REVISION BY DATE
SENCORE
ADDISON, ILL. 60101
NAME Ohms + Current adj. Board 500B
FIGURE 8
FINISH
BY TJG DATE 12-7-79
MODEL PM 5X


ALL DIMENSIONS ARE IN INCHES
TOL. UNLESS SPECI
DEC. FRAC.
±.010" ±.030
$I_{LIMIT} \approx 120mA$
CR1
IN4004's
CR2
R1
R2
R3
R4
C1
47mf 25VDC
115VAC
HEVAC
CR3
6.2V TC2 5%
12 VOLT ADJ
TL081 IC1
TR2 MJE180
CR4 IN4148
1.2K R8
680 5% R10
MJE180 TR3
820 5% R11
+7.5V
125K 1% R12
820 5% R13
MJE170 TR4
390 5% R15
R14 100K 1%
TL081 IC2
TR5 2N6
R16
-12V
5Ω R9 1/4WATT
5Ω R17 1/4WATT
UNREG. +8V
+5V
C3
C4
P.S. GND
C5
CR5
CR6
10VAC
CR7
CR8
CR9
CR10
IN4004's
78M05 IC3
C6 2000mf 25VDC
C7 .1mf
CURRENT
DCC 20mA
ACC 20mA
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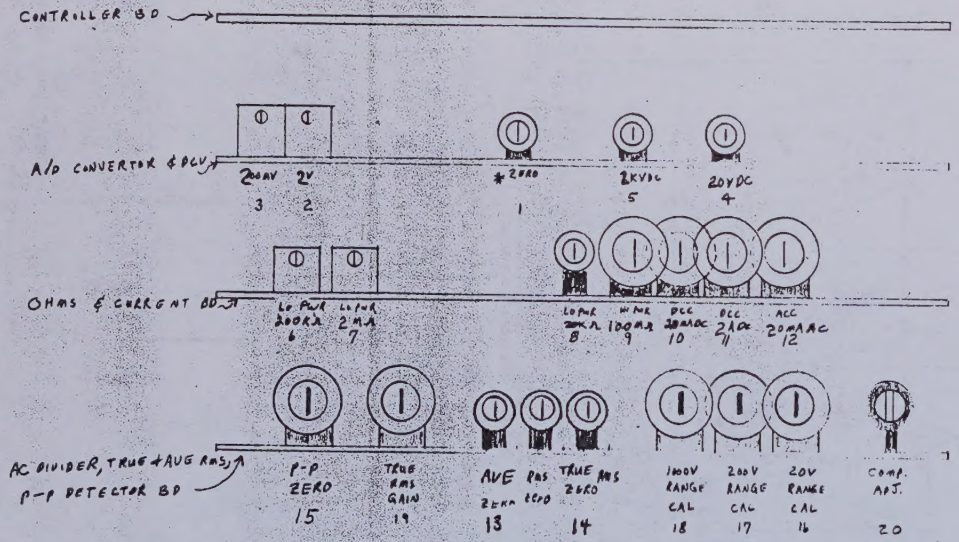
SYM. REVISION
SENCORE
ADDISON, ILL. 60101
NAME Power Supply
FIGURE 9
BY TJG DATE 9-12-79
SCALE APPV
MODEL SV
SN

ALL DIMENSIONS ARE IN INCHES

TOL. UNLESS SPECIFIED				
DEC.	.0	.00	.000	HOLES
TOL.	± .030	± .010	± .005	± .003



* THIS POT HAS BEEN DELETED IN LATER DESIGN.

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SYM	REVISION	BY	DATE

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SIOUX FALLS, SO. DAK. 57107

NAME: CAL. ADJUSMENTS LAYOUT

FIGURE 10

FINISH

BY: TJG DATE: 9-19-77

MODEL: DUM 56

SCALE: ~ APPV

NO.